

INTERIM

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# Interim Progress Report

## EXHIBIT "A"

Contract NAG8-293, Subcontract No. SUB93-101

### USE OF PHOTOSTRESS TO ANALYZE BEHAVIOR OF AN AFT SKIRT TEST SPECIMEN

Submitted to

NASA/MSFC  
through  
The University of Alabama  
in Huntsville  
Huntsville, Alabama

Prepared by

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December 26, 1992 - July 26, 1993

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(NASA-CR-194575) USE OF  
PHOTOSTRESS AND STRAIN GAGES TO  
ANALYZE BEHAVIOR OF WELDMENTS AND  
USE OF PHOTOSTRESS AND STRAIN GAGES  
TO ANALYZE BEHAVIOR OF AN AFT SKIRT  
TEST SPECIMEN Semiannual Report, 26  
Dec. 1992 - 26 Jul. 1993 (Alabama  
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**NAG8-293**

**FNAS/Summer Faculty Fellowship Research Continuation Program**

**Entitled**

*Use of Photostress and Strain Gages to Analyze Behavior of Weldments  
and*

*Use of Photostress and Strain Gages to Analyze Behavior of an  
Aft Skirt Test Specimen*

**SEMI - ANNUAL REPORT**

**December 26, 1992 - July 26, 1993**

*Submitted to*

**National Aeronautics and Space Administration  
George C. Marshall Space Flight Center  
Marshall Space Flight Center, AL 35812**

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**October 27, 1993**

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## INTRODUCTION

Previous work using Photostress on TIG welded, heat treated specimens of 2219-T87 parent material and 2319 weld material indicated that behavior of the joint can be highly irregular and non-uniform (1,2). Welded joints 1.40 inches thick exhibited a totally non-uniform behavior through the weld thickness with the "wide" side of the weld being much more ductile than the "narrow" side (see Figure 6). It is believed that this difference in behavior through the weld is, in part, caused by procedures used when laying the weld bead.

Joints similar to those tested in references 1 and 2 are an integral part of the aft skirt of the SRB of the shuttle. Since the ultimate safety factor for the lower portion of the weld is below the minimum required safety factor, a Photostress analysis of this lower portion will be conducted in the vicinity of the weld (see Figure 3). A test program using Photostress will be conducted in accordance with the project planning document entitled "Photostress Evaluation Requirements for AFT Skirt Test Article No. 4"(3).

## PROGRESS TO DATE

With reference to identification of the "wide" and "narrow" sides of the weld mentioned above, Figure 6 indicates the surfaces so identified as well as the "through the weld" view of the 1.4" thick weld.



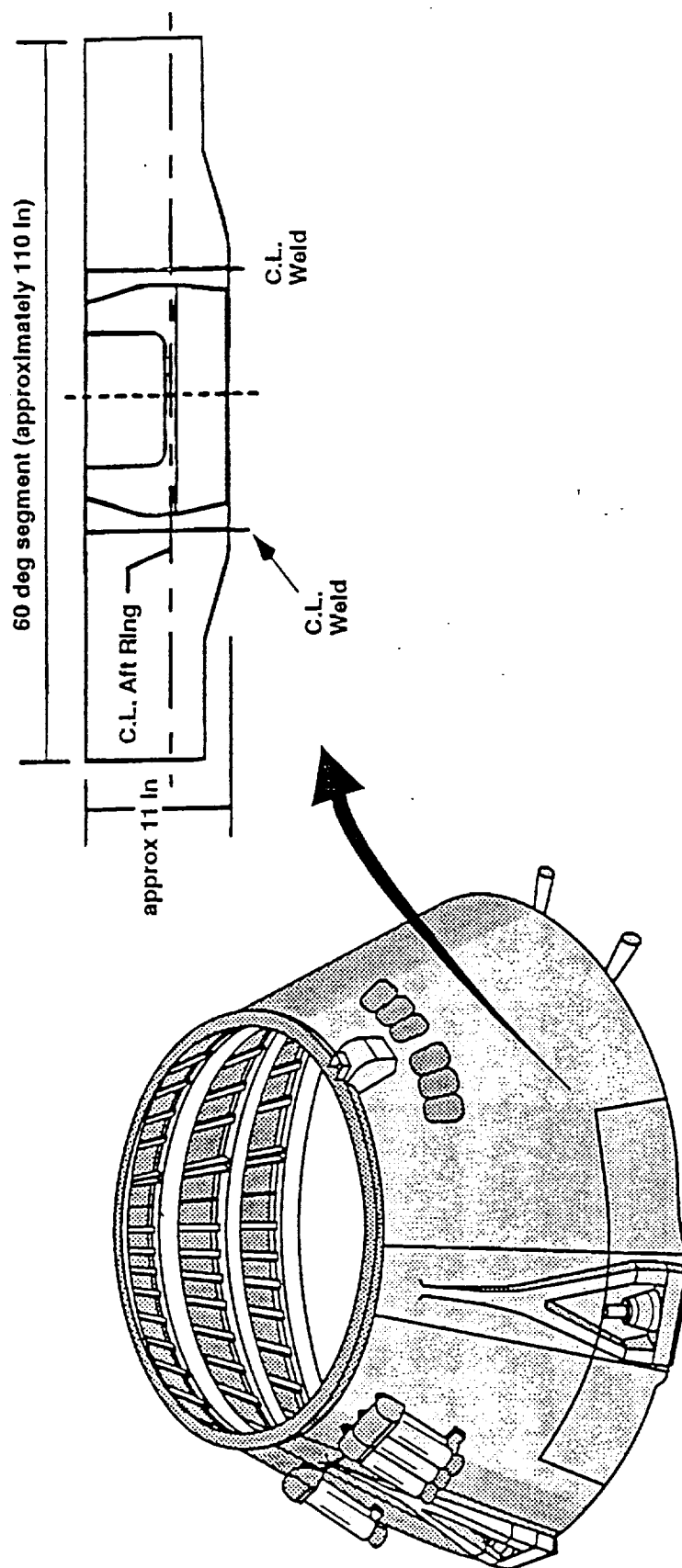


FIGURE 3 TEST SPECIMEN

- A. Calculations indicate that the photoelastic coating used on the aft skirt should to be 0.067 inches thick for measurement of maximum shearing strains of  $8,500 \times 10^{-6}$  within five fringe orders.
- B. Correction factors for the photoelastic coating and stress separator gages have been calculated as 0.96 and 0.92 respectively.
- C. A preliminary investigation of the critical region of the aft skirt has been conducted which included all steps required for the final investigation of the aft skirt to be received at MSFC in August or September, 1993. Pertinent information/results obtained from the preliminary investigation are listed in the following:
  - 1. Photoelastic coatings were poured, contoured, and attached by NASA personnel to the aft skirt hold-down post as seen in Photos 1 and 2. The average thickness of the coating was 0.0731 inches with a standard deviation of 0.0043 inches. Within plus or minus two standard deviations, this variation produced an overall accuracy in measuring shearing strains of

$$\gamma_{\text{reading}} \pm 12\%.$$

For the test of the aft skirt during the Fall of 1993, it has been decided to order the contourable photoelastic coatings from Measurements Group in Raleigh, NC, to reduce the percent scatter in readings



Photo 1. View of Hold-Down Post with Photoelastic Coating



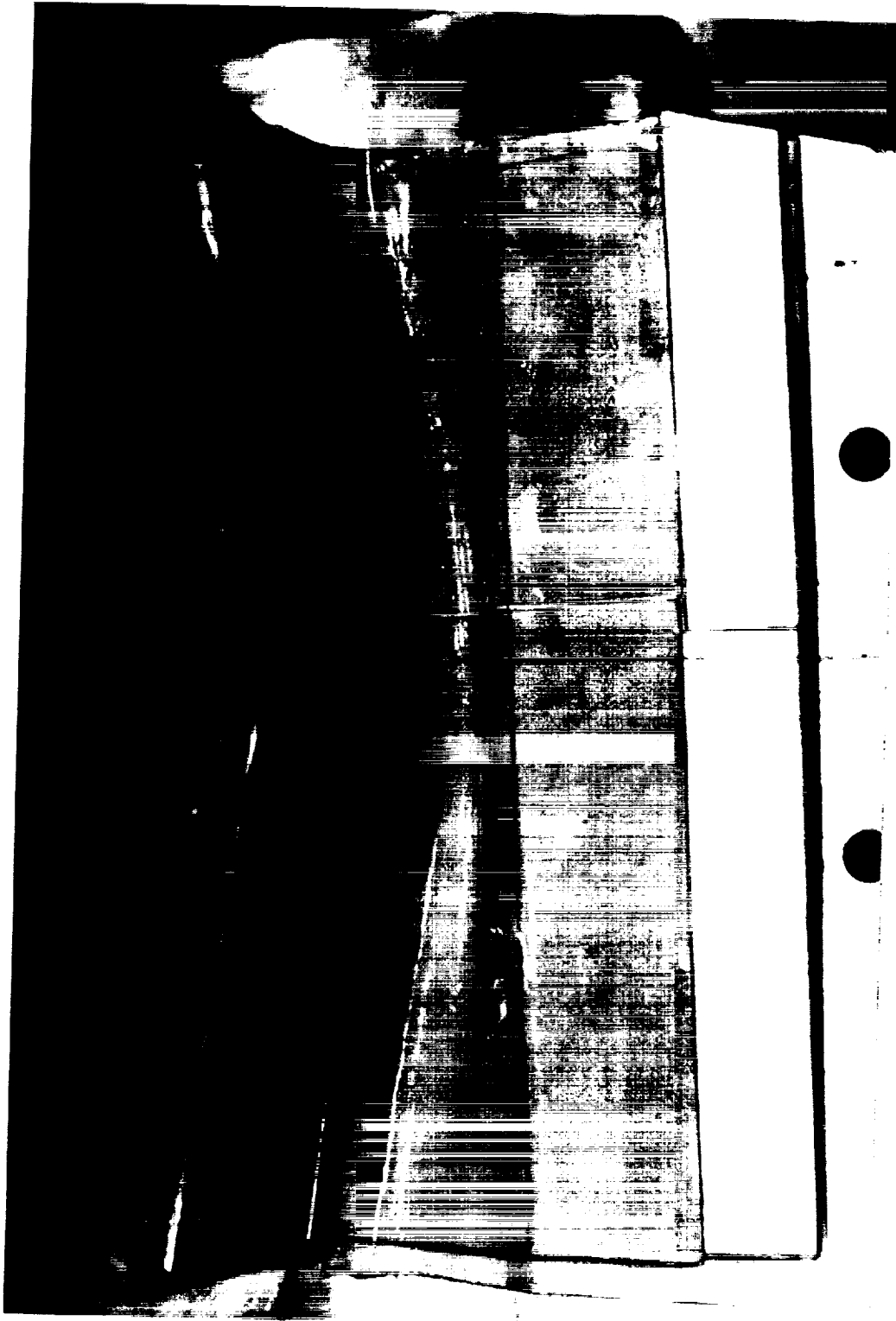


Photo 2. Close-Up of Photoelastic Coating

ORIGINAL PAGE  
COLOR PHOTOGRAPH

of shearing strain due to thickness variation of the coating to nearly zero.

Photo 1 shows the hold-down post with the photoelastic coating near the right end at the critical area and Photo 2 is a close-up of the coated critical area.

2. A grid network, approximating that which will be used during the Fall test of the aft skirt, can be seen in Photo 3. Sixty-four (64) points are identified for measurement of shearing strain including twelve (12) at which photostress separator gages will be used to separate the principal strains. (See Figure 3-1).
3. Photo 4 includes a series of fringe patterns produced when the hold-down post was loaded with a hydraulic jack in the manner seen in Figure 4. The force provided by the jack is given under each picture. One can clearly see the region of highest shearing strain between points 34 and 41 along the line one-half inch to the right of the centerline of the weld (points 18-30). Between points 34 and 41, the highest shearing strain of  $1728 \times 10^{-6}$  occurred at point 37. For the aft skirt test in the Fall, the highest shearing strain is expected to be approximately 4 to 5 times the value given here and will not necessarily be along the line including points 34 through 41.

Prior to receipt of the #4 aft skirt test specimen in the Fall of 1993, photoelastic coatings, adhesive, stress separator gages, and film will be ordered to provide for instrumentation of

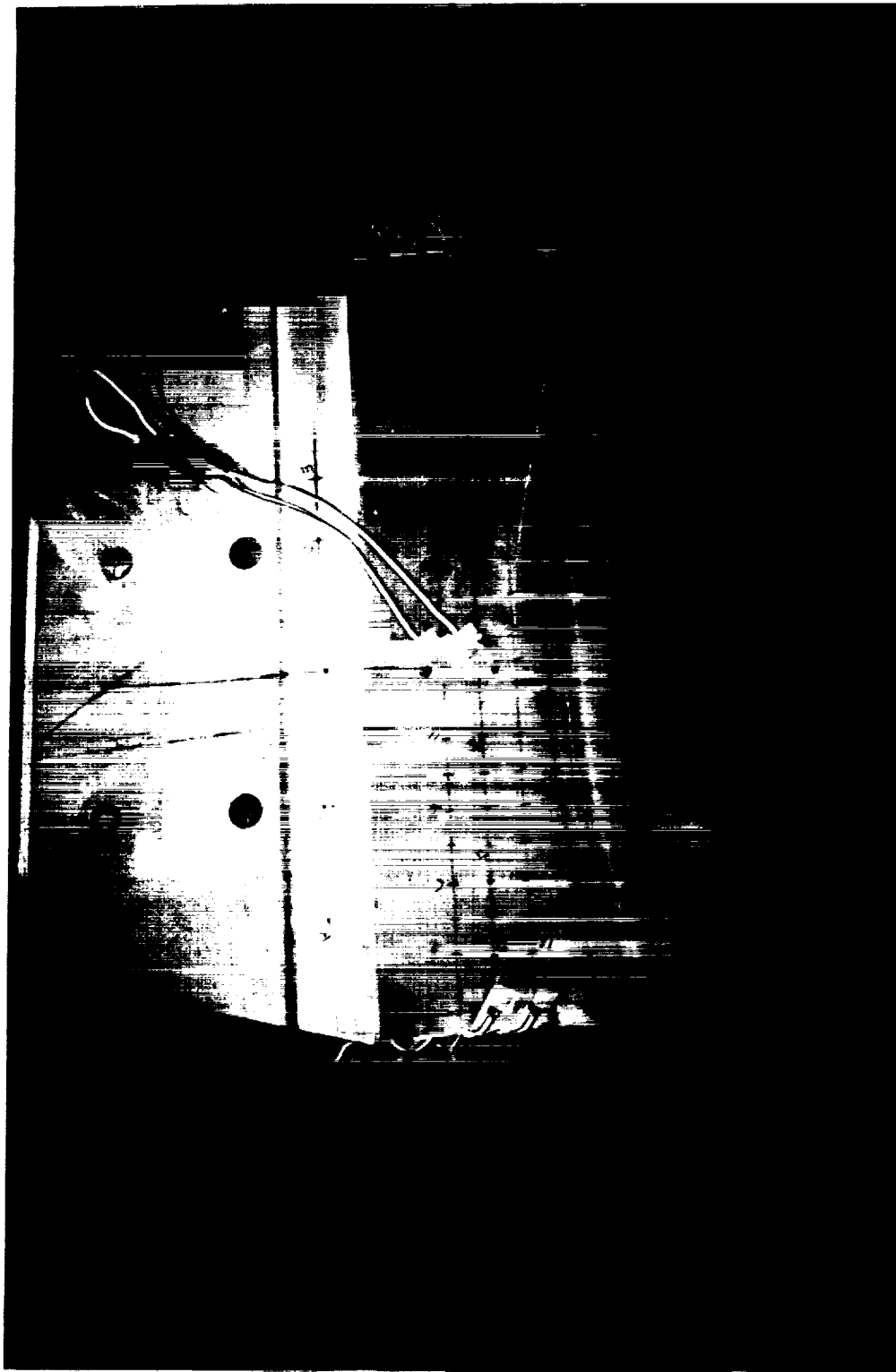


Photo 3. Top View of Photoelastic Coating  
Showing Grid Network and Four  
Stress Separator Gages

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COLOR PHOTOGRAPH

Separator Gages

The vertical distances are in exactly vertical direction.

Photostress Coating

Holddown Pin

Weld

2754-2

Separator Gages

The vertical distances are in exactly vertical direction.

Photostress Coating

Holddown Pin

Weld

2754-2

Technical drawing of a separator gage. The drawing shows a 3D perspective view of the gage. It has a rectangular base with a central rectangular cutout. The base is 3.0 units wide and 3.0 units high. The central cutout is 2.32 units wide and 2.75 units high. The gage is coated with a photostress coating. A holddown pin is shown at the top right. A weld is indicated on the right side. Dimensions are given in inches. The drawing is labeled with 'Separator Gages', 'The vertical distances are in exactly vertical direction.', 'Photostress Coating', 'Holddown Pin', and 'Weld'. The number '2754-2' is at the bottom right.

Separator Gages

The vertical distances are in exactly vertical direction.

Photostress Coating

Holddown Pin

Weld

2754-2

Separator Gages

The vertical distances are in exactly vertical direction.

Photostress Coating

Holddown Pin

Weld

2754-2

Separator Gages

The vertical distances are in exactly vertical direction.

Photostress Coating

Holddown Pin

Weld

2754-2

Technical drawing of a separator gage. The drawing shows a perspective view of a rectangular block with a central rectangular cutout. The block is labeled "Separator Gages" and "The vertical distances are in exactly vertical direction." Dimensions are provided in inches: 3.0, 4.42, 2.75, 1.0, 0.5, 1.02, 1.4, 2.32, and 0.5. A "Photo Stress Coating" is applied to the top surface. A "Weld" is shown on the right side. A "HOLDOWN PIN" is indicated at the bottom right.

Separator Gages

The vertical distances are in exactly vertical direction.

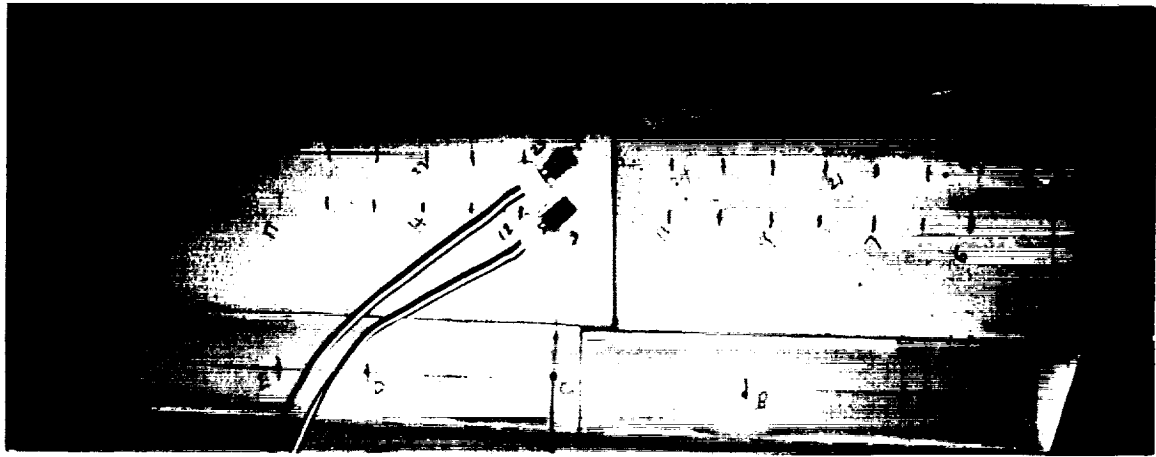
Photostress Coating

Holddown Pin

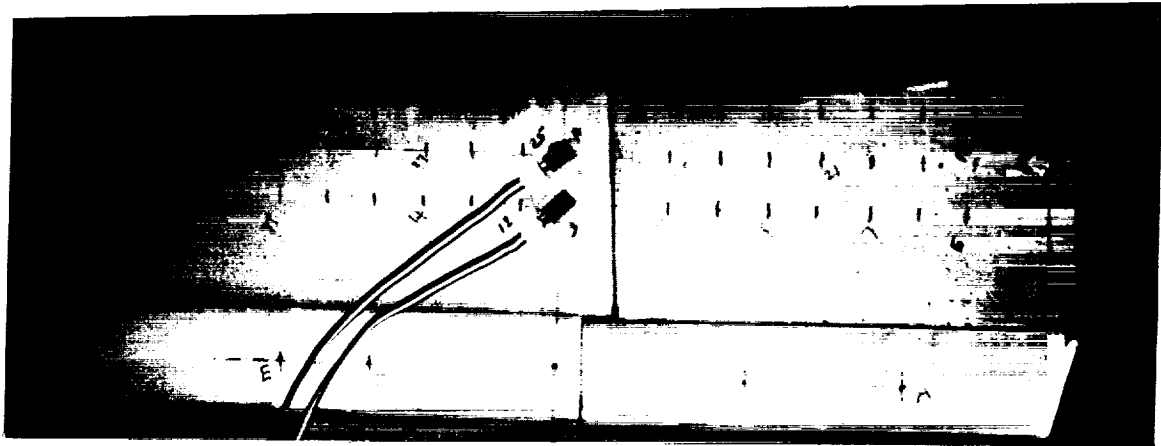
Weld

2754-2

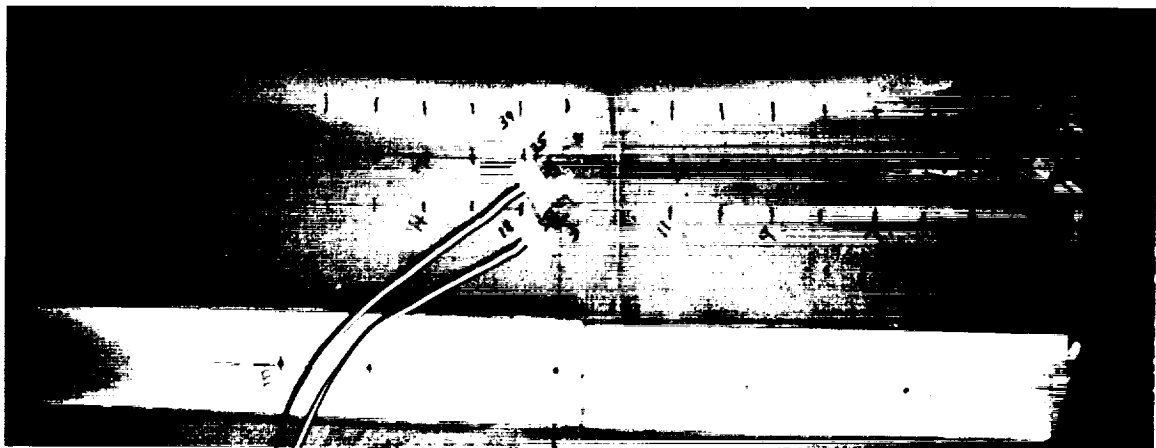
Technical drawing of a separator gage. The drawing shows a perspective view of a rectangular block with a central vertical slot. The block is divided into two main sections by a vertical plane. The left section has a width of 3.0. The right section has a width of 3.0. The total width is 6.0. The height of the block is 1.0. The central slot has a width of 0.25. The distance from the left edge to the center of the slot is 2.75. The distance from the right edge to the center of the slot is 2.75. The total distance across the slot is 5.5. The drawing also shows a holddown pin on the right side and a weld on the left side. The photostress coating is indicated on the top surface. Dimensions are given in inches.



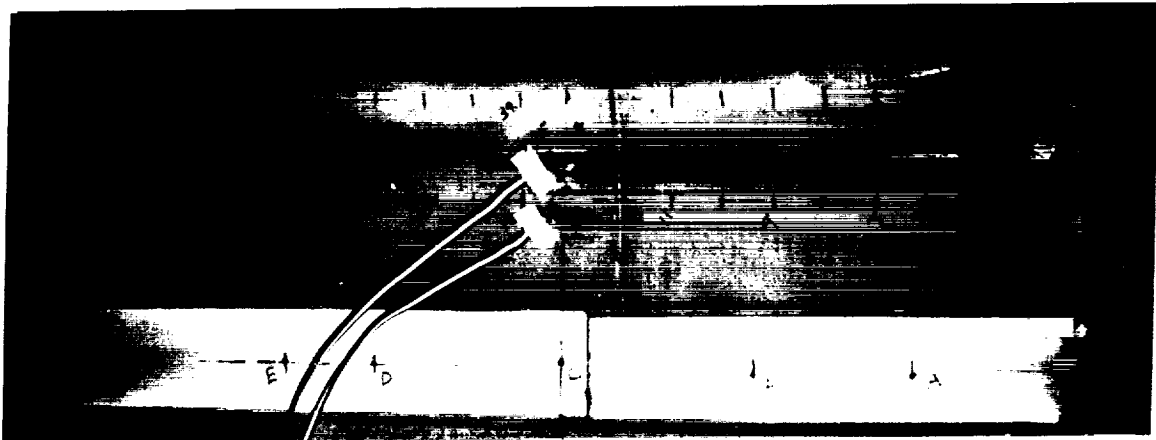
9621 lbs



7216 lbs



4810 lbs



2405 lbs

Photo 4. Fringe Patterns for Applied Loads

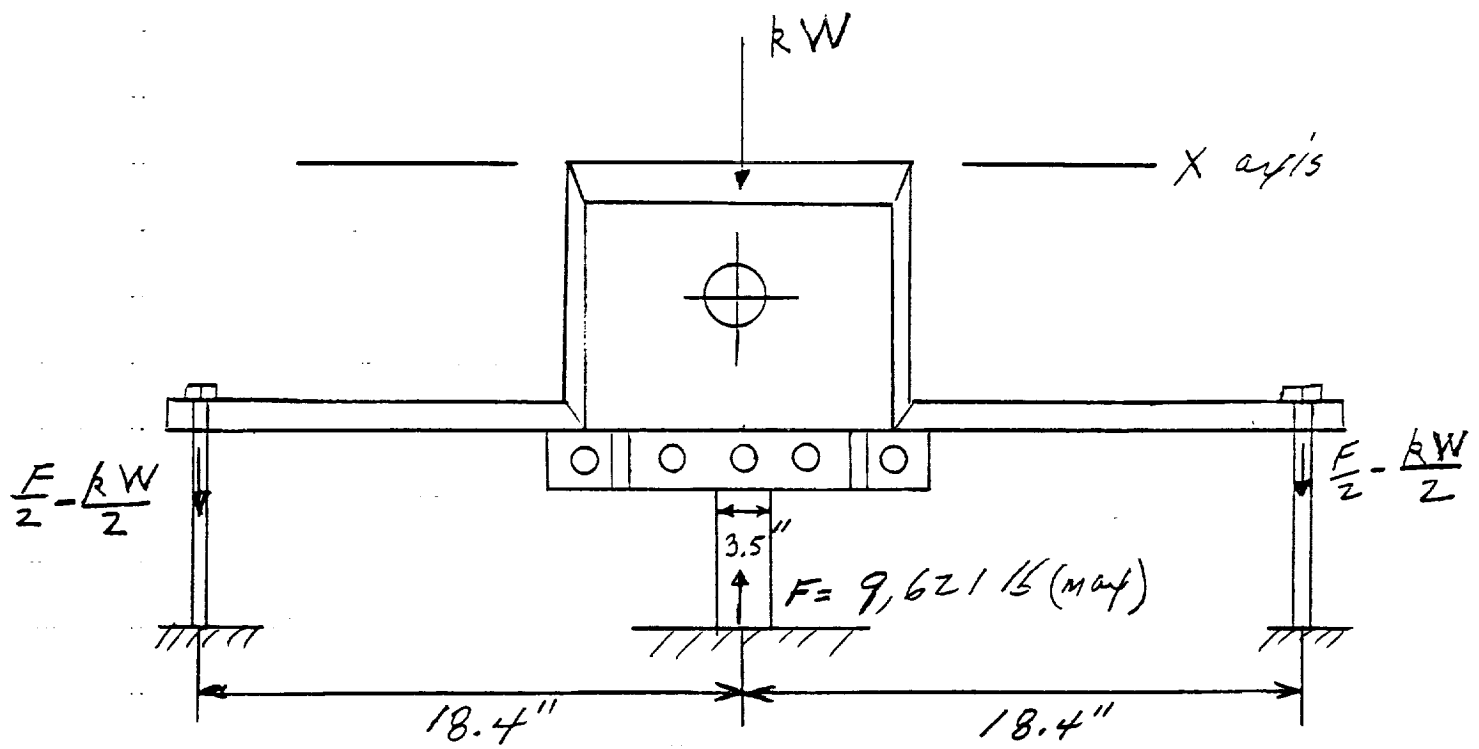


Figure 4. Rear View of Hold-Down Post

the specimen and recording of fringe patterns. No additional work is anticipated until a notice of shipment of the aft skirt test specimen is received.

#### REFERENCES

1. Gambrell, S. C., Jr., "Use of Photostress to Characterize the Mechanical Behavior of Weldments," Summary of Work, NASA/ASEE Summer Fellowship Program, Metallurgy Research Branch, Metallic Materials Division, Materials and Processes Laboratory, MSFC, May 28 - August 2, 1991.
2. Gambrell, S. C., Jr., "Use of Photostress to Characterize the Mechanical Behavior of Weldments," Final Report, Contract No. NAG8-212, SUB92-195, University of Alabama in Huntsville/NASA, BER Report No. 570-97, September, 1992.
3. Nigam, R. K., "Aft Skirt Weld Factor of Safety Improvement Project-Photostress Evaluation Requirements for AFT Skirt Test Article No. 4," USBI-ANAL-263-93, February 1993.